Thermal equilibrium of cold clouds in PKS 0745-191 [1]

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Abstract. PKS 0745-191 is a powerful radio source with one of the largest known cooling flows [1]. A fraction of the cool gas could accumulate into small molecular clouds. We studied the minimum temperature which can be reached by sub-clouds (resulting from the fragmentation of bigger clouds) in the cooling flow region.

1 Introduction

Molecules such as H_2 and HD are expected to be present in the post-recombination gas and due to their cooling properties they can thermally influence the gravitationnal collapse of the first objects which formed in the Universe [2]. At low temperatures, these molecules with some traces of CO could also be present in the intracluster gas, where they could act as important coolant in cooling flows. In this chemically simple gas the molecules are mainly excited collisionally. Followed by a radiative de-excitation in the optically thin medium this leads to an energy loss for the gas clouds and thus to a cooling.
The aim of this communication is to discuss the minimum temperature achievable by clouds located in the region of the cooling flow of PKS 0745-191.

2 Equilibrium distance

We have computed the molecular cooling (including radiative transfer effects) due to H_2, HD and CO for small clouds which are the result of a fragmentation process of bigger clouds in cooling flows [3].
In our calculation we included also an attenuation factor τ which caracterizes the column density surrounding the sub-clouds. Thus the attenuated bremsstrahlung flux coming from the intracluster gas heats the clouds located in the cooling flow at a distance r from the cluster center, and so thermal balance between heating and cooling defines an equilibrium temperature of the sub-clouds at a distance $r = R_{eq}$ inside the cooling flow region (i.e. $R_{eq} < r_{cool}$).

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The following column densities are adopted for a typical small cloud (with $n_{H_2} = 10^6 \mathrm{cm}^{-3}$ and the orto-para ratio equal to 1):
$N_{CO} = 10^{14}\,\mathrm{cm}^{-2}$ and $N_{H_2} = 2 \times 10^{18}\,\mathrm{cm}^{-2}$, which corresponds to a CO abundance: $\eta_{CO} \sim 5 \times 10^{-5}$. For HD instead we assume the primordial ratio $\eta_{HD} \sim 7 \times 10^{-5}$.

In Figure 1 we plotted the equilibrium temperature of clumps at the equilibrium distance R_{eq} for different values of the attenuation factor τ. We see that low equilibrium temperatures are achieved at distances smaller than the cooling radius r_{cool}. In Figure 2 we plotted the equilibrium distance as a function of the

Figure 1
Equilibrium Distance

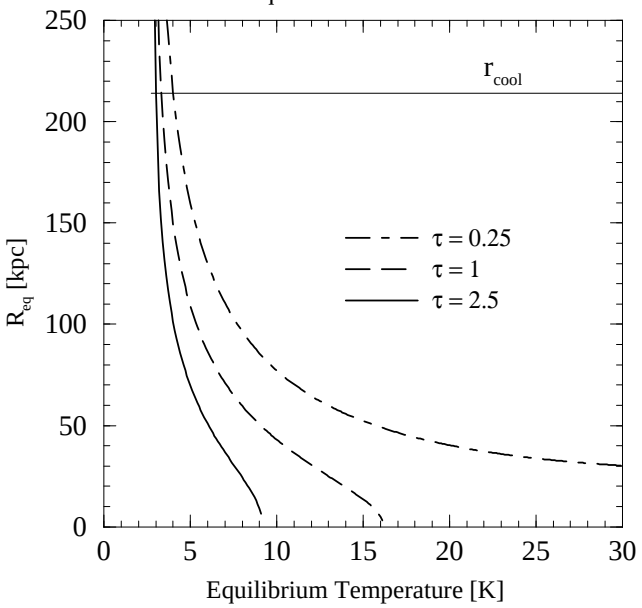
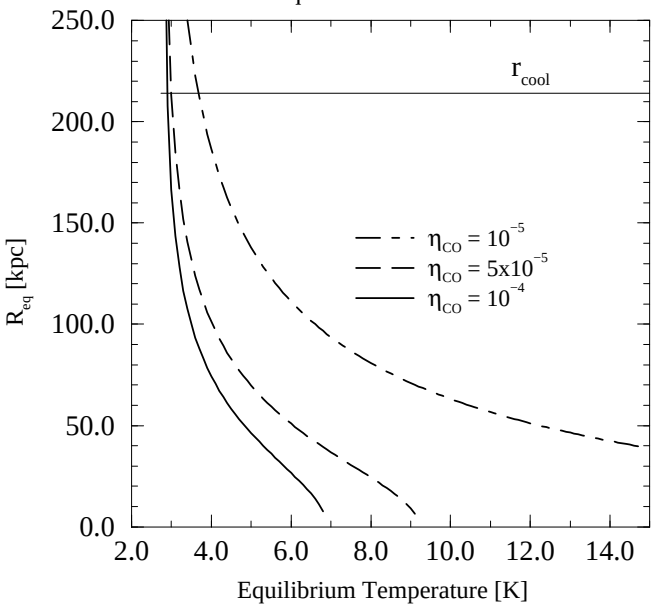


Figure 2
Equilibrium Distance



equilibrium temperature for different values of η_{CO} and $\tau = 2.5$ is kept fixed. Indeed, the CO abundance and thus η_{CO} is an important parameter which is, however, not well known.

We thus find that a fraction of the gas in the cooling flow of PKS 0745-191 could be very cold, which might form small clouds via fragmentation.

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